Neuromodulation
KI in der Schmerztherapie

Frequenzen und Indikationen

AISSP e.V.

Arbeitsgemeinschaft für Interdisziplinäre
Spezielle Schmerz- und Palliativmedizin

Programm | 04. – 06.03.2026

JAHRESKONGRESS

Schmerzmedizin im Wandel:
Gestern, Heute, Früher – bleibt alles anders?

Disclaimer

Consultant, honorary fees, travel grants, humanitarian grants, study funding, principal investigator

President DGNM eV

Abbott

BostonScientific

Esteve

Medtronic

Nevro Germany/Globus

UKSH Academy

Inhalt

- *Allgemein*
- *SCS*
- *What´s next?*

Übersicht mit KI

Künstliche Intelligenz (KI) ist ein Teilgebiet der Informatik, das darauf abzielt, menschliches Lernen und Denken auf Computer zu übertragen, um Aufgaben selbstständig zu lösen. Sie umfasst Technologien wie maschinelles Lernen und neuronale Netze, die Muster in großen Datenmengen erkennen und Prozesse optimieren. KI findet Anwendung in Übersetzungstools, Medizin, Robotik und der Analyse von Daten, erfordert aber oft hohe Rechenleistung. Fraunhofer IKS +3

Artificial intelligence

From Wikipedia, the free encyclopedia

"AI" redirects here. For other uses, see AI (disambiguation) and Artificial intelligence (disambiguation).

Artificial intelligence (**AI**) is the capability of computational systems to perform tasks typically associated with human intelligence, such as learning, reasoning, problem-solving, perception, and decision-making. It is a field of research in computer science that develops and studies methods and software that enable machines to perceive their environment and use learning and intelligence to take actions that maximize their chances of achieving defined goals.[1]

High-profile applications of AI include advanced web search engines (e.g., Google Search); recommendation systems (used by YouTube, Amazon, and Netflix); virtual assistants (e.g., Google Assistant, Siri, and Alexa); autonomous vehicles (e.g., Waymo); generative and creative tools (e.g., language models and AI art); and superhuman play and analysis in strategy games (e.g., chess and Go). However, many AI applications are not perceived as AI: "A lot of cutting edge AI has filtered into general applications, often without being called AI because once something becomes useful enough and common enough it's not labeled AI anymore."[2][3]

Part of a series on
Artificial intelligence (AI)

Major goals	[show]
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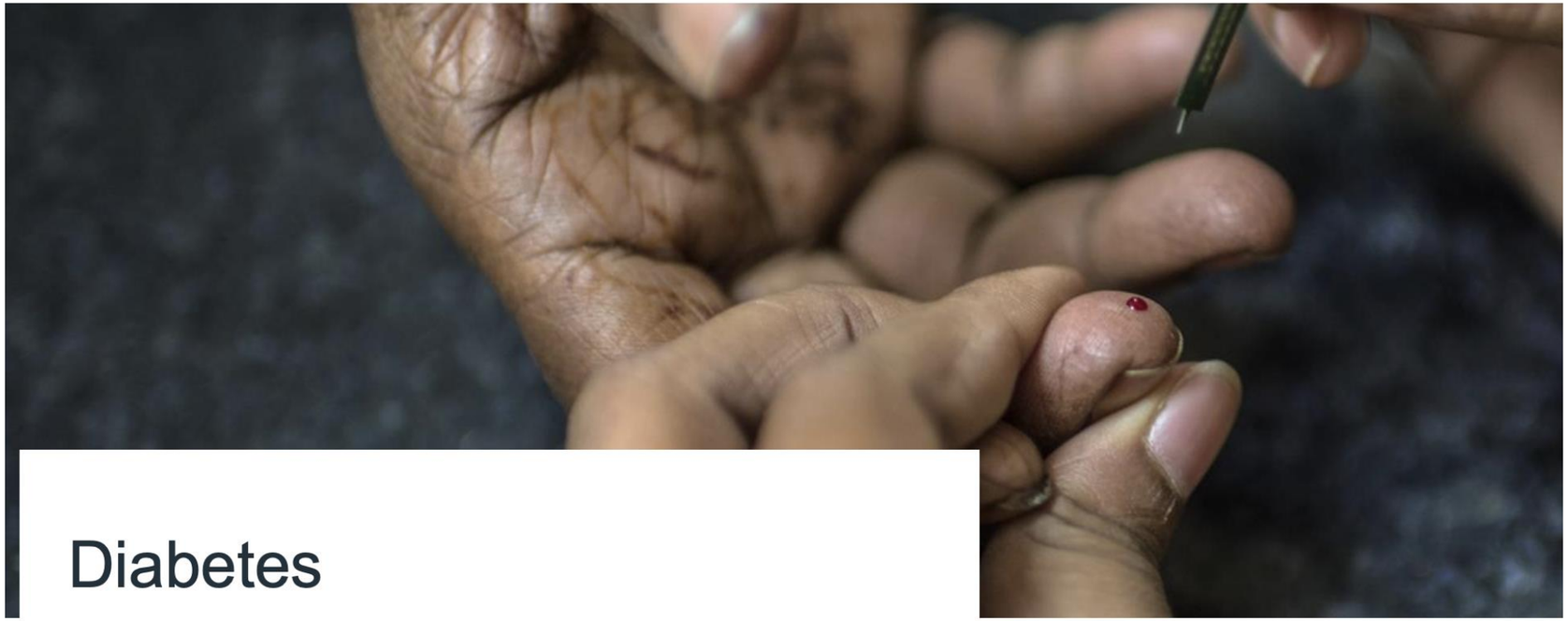

Diabetes

Overview | Symptoms | Treatment

Obesity and overweight

8 December 2025

Key facts

- In 2022, 1 in 8 people in the world were living with obesity.
- Worldwide adult obesity has more than doubled since 1990, and adolescent obesity has quadrupled.
- In 2022, 2.5 billion adults (18 years and older) were overweight. Of these, 890 million were living with obesity.
- In 2022, 43% of adults aged 18 years and over were overweight and 16% were living with obesity.
- In 2024, 35 million children under the age of 5 were overweight.
- Over 390 million children and adolescents aged 5–19 years were overweight in 2022, including 160 million who were living with obesity.

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Web statement on pain management guidance

20 JUNE 2019 - WHO takes very seriously concerns recently raised about the development of its 2011 guidance “Ensuring balance in national policies on controlled substances: Guidance for availability and accessibility of controlled medicines”, as well as its 2012 “WHO guidelines on the pharmacological treatment of persisting pain in children with medical illnesses”.

WHO is discontinuing these guidelines in light of new scientific evidence that has emerged since the time of their publication. This will also address any issues of conflicts of interest of the experts that have been raised.

WHO remains fully committed to ensuring that people suffering severe pain have access to effective pain relief medication, including opioids. WHO is concerned that there is very low access to medication for moderate and severe pain, particularly in low and middle-income countries.

WHO also recognizes that the need for access to pain relief must be balanced with concerns about the harm arising from the misuse of medications prescribed for the management of pain, including opioids. Scientific evidence indicates there are risks associated with the use of these medications —such as the development of dependence, overdose and accidental death. Even when prescribed according to established clinical guidelines and patients’ needs, and used as directed, certain factors may increase these risks.

Neuromodulation: Technology at the Neural Interface

Received: March 26, 2024 Revised: May 3, 2024 Accepted: May 13, 2024

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A Visual and Narrative Timeline Review of Spinal Cord Stimulation Technology and US Food and Drug Administration Milestones

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ABSTRACT

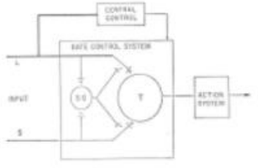
Objectives: The aim of this study was to present key technologic and regulatory milestones in spinal cord stimulation (SCS) for managing chronic pain on a narrative timeline with visual representation, relying on original sources to the extent possible.

Materials and Methods: We identified technical advances in SCS that facilitated and enhanced treatment on the basis of scientific publications and approvals from the United States (US) Food and Drug Administration (FDA). We presented milestones limited to first use in key indications and in the context of new technology validation. We focused primarily on pain management, but other indications (eg, motor disorder in multiple sclerosis) were included when they affected technology development.

Results: We developed a comprehensive visual and narrative timeline of SCS technology and US FDA milestones. Since its conception in the 1960s, the science and technology of SCS neuromodulation have continuously evolved. Advances span lead design (from paddle-type to percutaneous, and increased electrode contacts) and stimulator technology (from wireless power to internally powered and rechargeable, with miniaturized components, and programmable multichannel devices), with expanding stimulation program flexibility (such as burst and kilohertz stimulation frequencies), as well as usage features (such as remote programming and magnetic resonance imaging conditional compatibility).

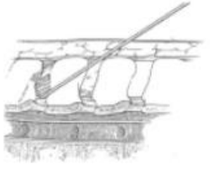
Conclusions: This timeline represents the evolution of SCS technology alongside expanding FDA-approved indications for use.

Keywords: Key milestones, narrative timeline, neuromodulation, pain management, review article, spinal cord stimulation



1965
Gate control theory of pain
Suggests electrical stimulation can reduce pain

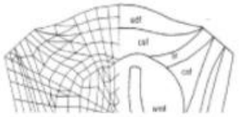
1968
First commercial SCS system



1967
Peripheral and dorsal column stimulation
Successfully tested for pain

1972-1977
Percutaneous implanted leads
For use in SCS are developed

1978-1979
FDA classifies and approves SCS
To relieve severe intractable pain



1980-1985
First-generation SCS computational models
Support mechanisms and computer-driven design

1981-1988
Multi-contact leads
Enhance patient-specific tuning

1981-1984
Fully implanted pulse generators developed
And receive FDA label for "chronic intractable pain for the trunk and upper limbs"

1985-1995
Second-generation SCS computational models
Enhance computer-driven analysis and design

1987-1998
Computer-assisted programming in SCS
Is pioneered

2000
FDA expands indications for SCS
To include FBSS and other conditions

1991-1996
Multi-channel and multi-program SCS therapies
Enhance outcomes and durability

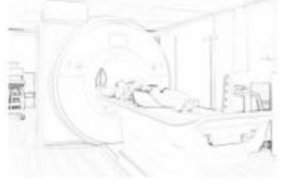
2004-2014
Continued advancement in stimulator and leads
Technology allows wider scope of patient-tuned programming

2004
Rechargeable SCS devices
Enhance patient wellbeing and reduce complications from device replacements

2006
SCS pain relief without paresthesia developed

2011-2013
Sensor-driven (closed-loop) SCS is developed

2013
FDA approves MRI-conditional SCS devices



2014-2021
Miniaturized SCS implants are developed

2015-2017
SCS systems with expanding waveforms
Enhanced options for patient-tailored therapy including sub-paresthesia therapy

2021-2022
FDA expands SCS indications to include diabetic neuropathy and non-surgical back pain

2021-2023
FDA approves SCS with integrated remote telehealth features including AI

2022
FDA approves ECAP closed-loop SCS

1995-2023
Third-generation SCS computational models
Support circuit therapeutics, individualized therapy, and novel mechanisms

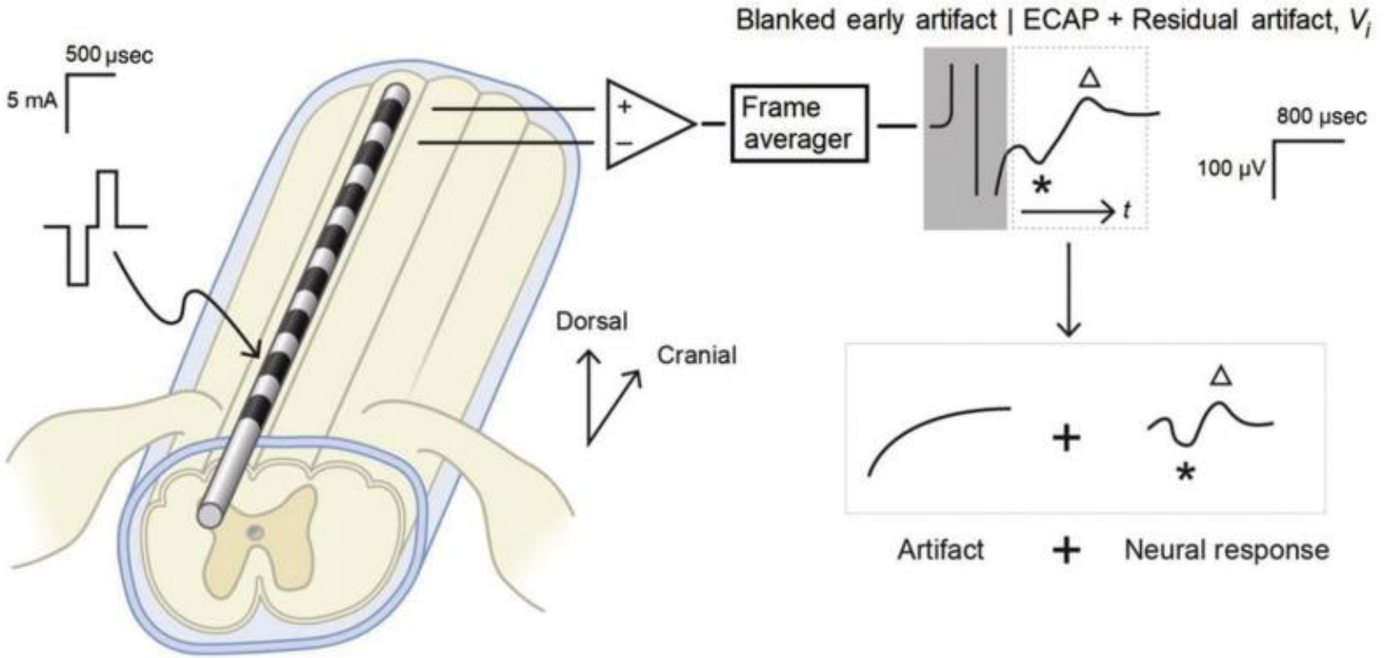
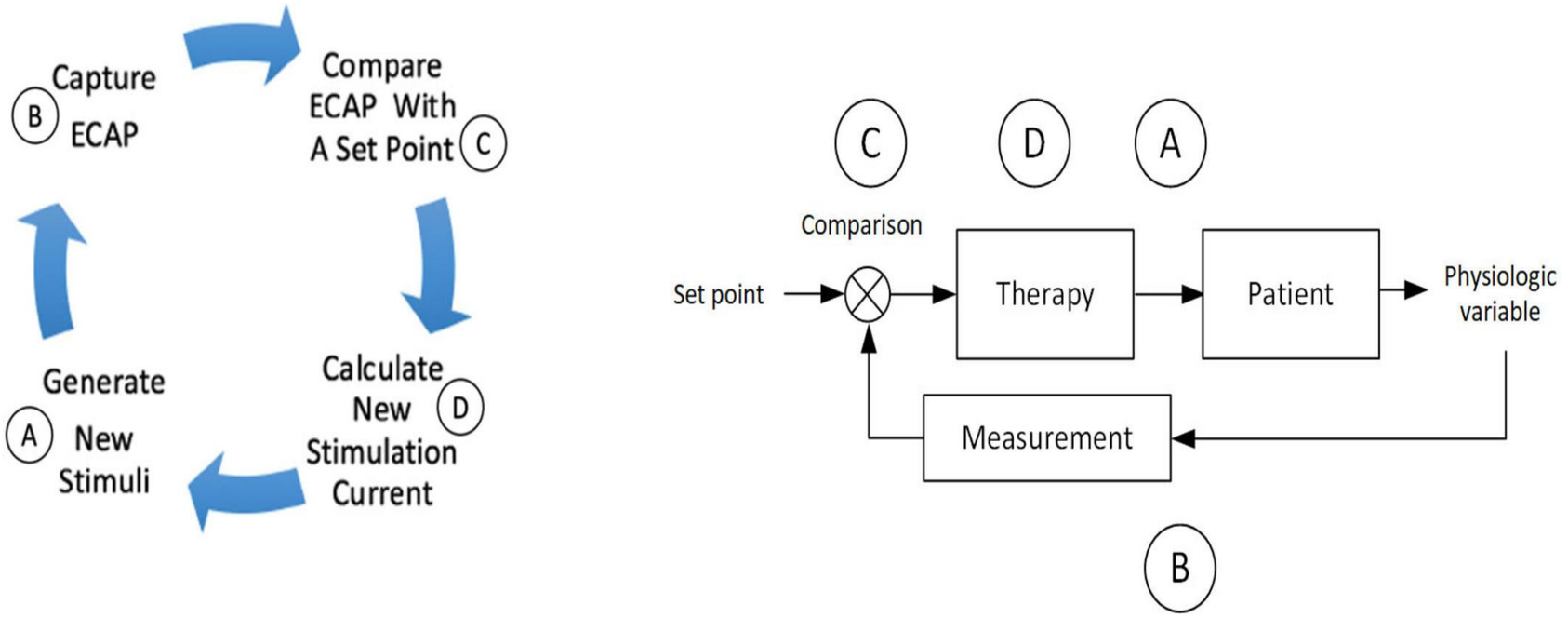


Figure 1. Processing of the spinal ECAP. Spinal cord stimulation is delivered to one end of the lead, and ECAPs are detected from the other. Averaging may be used to reduce noise. The recording itself consists of artifact as well as the evoked potential. While the portion of the artifact coincident with the stimulation pulse may be blanked out (shaded in gray), further processing is needed on the residual to limit artifact contamination on the true neural response. Here, the N1 and P2 features are marked with a * and Δ, respectively.

Closing the loop and raising the bar: Automated control systems in neuromodulation



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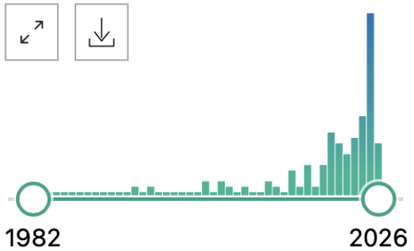

PUBLICATION DATE

- 1 year
- 5 years
- 10 years
- Custom Range

TEXT AVAILABILITY

1 Cite

Advances in targeted **closed loop** spinal cord stimulation to treat pain of the trunk and limbs.

Karcz MK, Bracero LA, Lester DD, Graca MJ, Gish BE, Deer TR.

Expert Rev Neurother. 2026 Feb 17:1-11. doi: 10.1080/14737175.2026.2632285. Online ahead of print.

PMID: 41681083 Review.

Closed-loop SCS (CL-**SCS**) using evoked compound action potential (ECAP) has overcome these limitations with the ability to measure spinal cord activation and accurately administer therapeutic doses despite the dynamic physiologic processes that affect ...

2 Cite

Selecting Neuromodulation Devices For Chronic Pain Conditions: A Narrative Review.

Wahezi S, Kaye AD, Yener U, Hunter C, George TK, Bikson M, Caparo M, Day M, Eshraghi Y, Kaufman A, Zhang H, Pak D, Pritzlaff S, Cifti HB, Shaparin N, Schatman M, Lempka S, Manchikanti L.

Pain Physician. 2026 Jan;29(1):17-36.

PMID: 41628204 **Free article.** Review.

TABLE 1 Automated Control System-based neuromodulation devices approved for use in the United States.

Automated control system	Year approved (US)	Method of control	Physiological closed loop-control system?	Response times
Spinal cord stimulation for pain (Medtronic) – Patient positions are programmed with different stimulation settings and micro-accelerometers determine when the patient has changed into those positions, signaling to the IPG to change the program[14]	2011	Feedforward	No	Seconds – minutes
Cortical stimulation for intracranial seizure detection/stimulation (NeuroPace) – once seizure foci have been identified in a patient through invasive or external monitoring, electrodes placed are placed at the seizure foci for continuously recording and sophisticated algorithms can detect a potential onset of a seizure. Stimulation at or nearby the seizure foci can ameliorate or stop the seizure from starting or propagating[22]	2013	Closed-loop feedback	Yes	Milliseconds –seconds
Vagal nerve stimulation for seizures (LivaNova) – IPG continuously detects patient heartrate and delivers stimulation to the vagal nerve when the heartrate increases above a programmed threshold (approximately 80% of seizures show an increase in heartrate at seizure onset or just prior to onset)[25]	2017	Feedforward	No	Seconds
Spinal cord stimulation for pain (Saluda Medical) – ECAP is recorded from the implanted electrode itself and continuously used to adjust the amplitude of the output signal so that the spinal cord receives an optimal amplitude to maintain a continuous target ECAP as it moves within the electric field potentials[24]	2022	Closed-loop feedback	Yes	Milliseconds

Abbreviations: ECAP, evoked compound action potential; IP, internal pulse generator.

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A Clinical Feasibility Study of Spinal Evoked Compound Action Potential Estimation Methods

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ABSTRACT

Objectives: Spinal cord stimulation (SCS) is a treatment for chronic neuropathic pain. Recently, SCS has been enhanced further with evoked compound action potential (ECAP) sensing. Characteristics of the ECAP, if appropriately isolated from concurrent stimulation artifact (SA), may be used to control, and aid in the programming of, SCS systems. Here, we characterize the sensitivity of the ECAP growth curve slope (S) to both neural response ($|S_{resp}|$) and SA contamination ($|S_{art}|$) for four spinal ECAP estimation methods with a novel performance measure ($|S_{resp}/S_{art}|$).

Materials and Methods: We collected a library of 112 ECAP and associated artifact recordings with swept stimulation amplitudes from 14 human subjects. We processed the signals to reduce SA from these recordings by applying one of three schemes: a simple high-pass (HP) filter, subtracting an artifact model (AM) consisting of decaying exponential and linear components, or applying a template correlation method consisting of a triangularly weighted sinusoid. We compared these against each other and to P2-N1, a standard method of measuring ECAP amplitude. We then fit the ECAP estimates from each method with a function representing the growth curve and calculated the S_{resp} and S_{art} parameters following the fit.

Results: Any SA reduction scheme selected may result in under- or overestimation of neural activation or misclassification of SA as ECAP. In these experiments, the ratio of neural signal preservation to SA misclassification ($|S_{resp}/S_{art}|$) on the ECAP estimate was superior ($p < 0.05$) with the HP and AM schemes relative to the others.

Conclusions: This work represents the first comprehensive assessment of spinal ECAP estimation schemes. Understanding the clinically relevant sensitivities of these schemes is increasingly important, particularly with closed-loop SCS systems using ECAP as a feedback control variable where misclassification of artifact as neural signal may lead to suboptimal therapy adjustments.

Keywords: Artifact, closed-loop, evoked compound action potentials, pain, spinal cord stimulation

Conflict of Interest: Dr. Chakravarthy has received consulting fees from Medtronic plc, Abbott, Boston Scientific, Mainstay Medical, MedinCell, Bioness, PAINTEQ, and Omnia Medical. Dr. Chakravarthy is on an advisory board for Medtronic plc and has stock options in Nalu Medical, Aya Biosciences, Higgs Boson Health, Mainstay Medical and Oska Wellness. Dr. Chakravarthy received research support from Medtronic, Abbott, and Bioness and serves as a consultant for Medtronic. Dr. FitzGerald has received consulting fees from Abbott, Boston Scientific, and Medtronic. Dr. FitzGerald is on an advisory board for Medtronic plc and serves as a consultant. Robert Corey, David Dinsmoor, and Dr. Litvak are employees of Medtronic plc and hold stock and stock options with Medtronic. Dr. Will and Karen Trutnau are consultants to Medtronic.

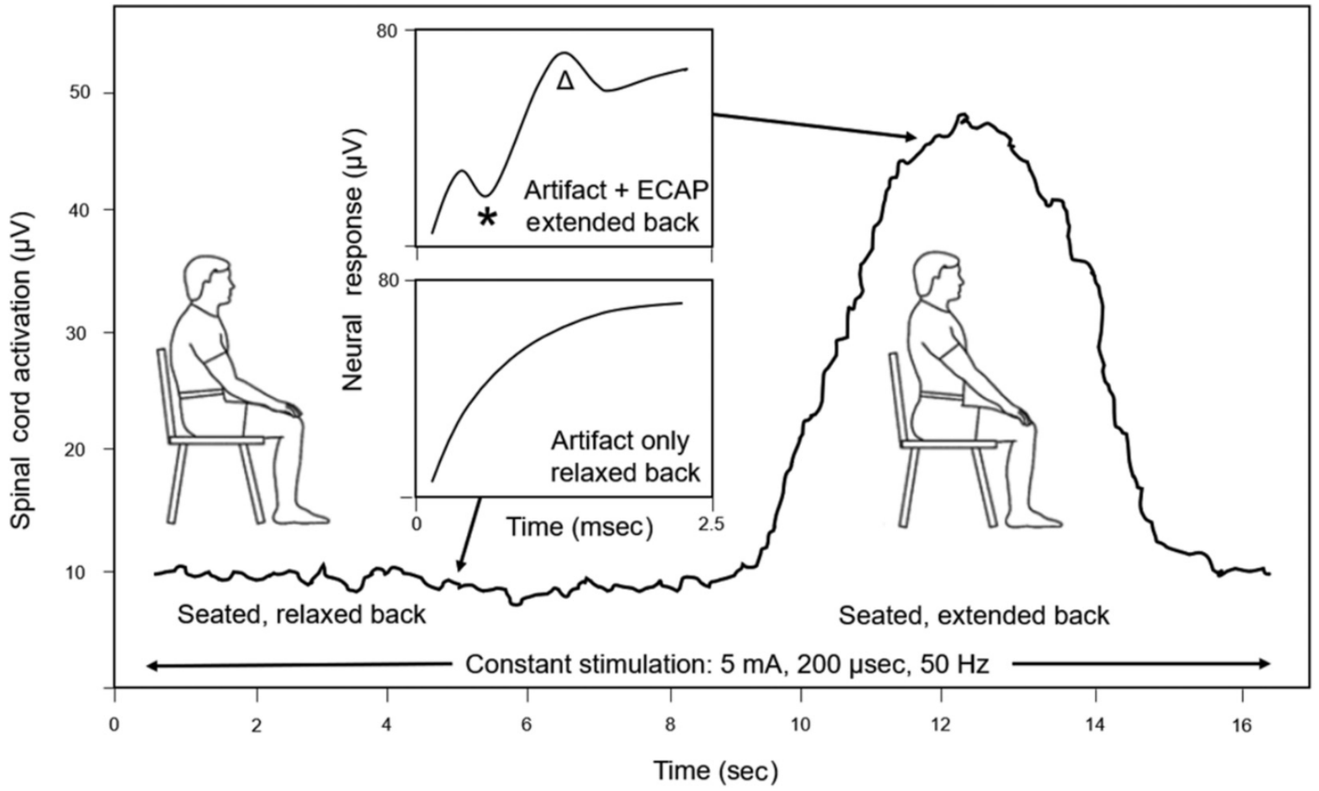

Figure 7. Exemplary ECAP amplitude and recordings during back extension. In this illustration, fixed parameter SCS is delivered to a patient before, during, and after a back extension. ECAP amplitudes are plotted continuously during these postural changes. Shown in the insets are individual recordings prior to and during the back extension. When the patient's back is relaxed, only artifact is detectable by the system. However—owing to overestimation of artifact as ECAP—a baseline 10-μV ECAP amplitude is nevertheless reported by the system. When the patient extends their back, the ECAP—with characteristic N1 (*) and P2 (Δ) features—manifests, superimposed on the recording.

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PAPER

Evoked compound action potentials during spinal cord stimulation: effects of posture and pulse width on signal features and neural activation within the spinal cord

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Keywords: chronic pain, computer simulation, evoked potentials, spinal cord, spinal cord stimulation

Supplementary material for this article is available online

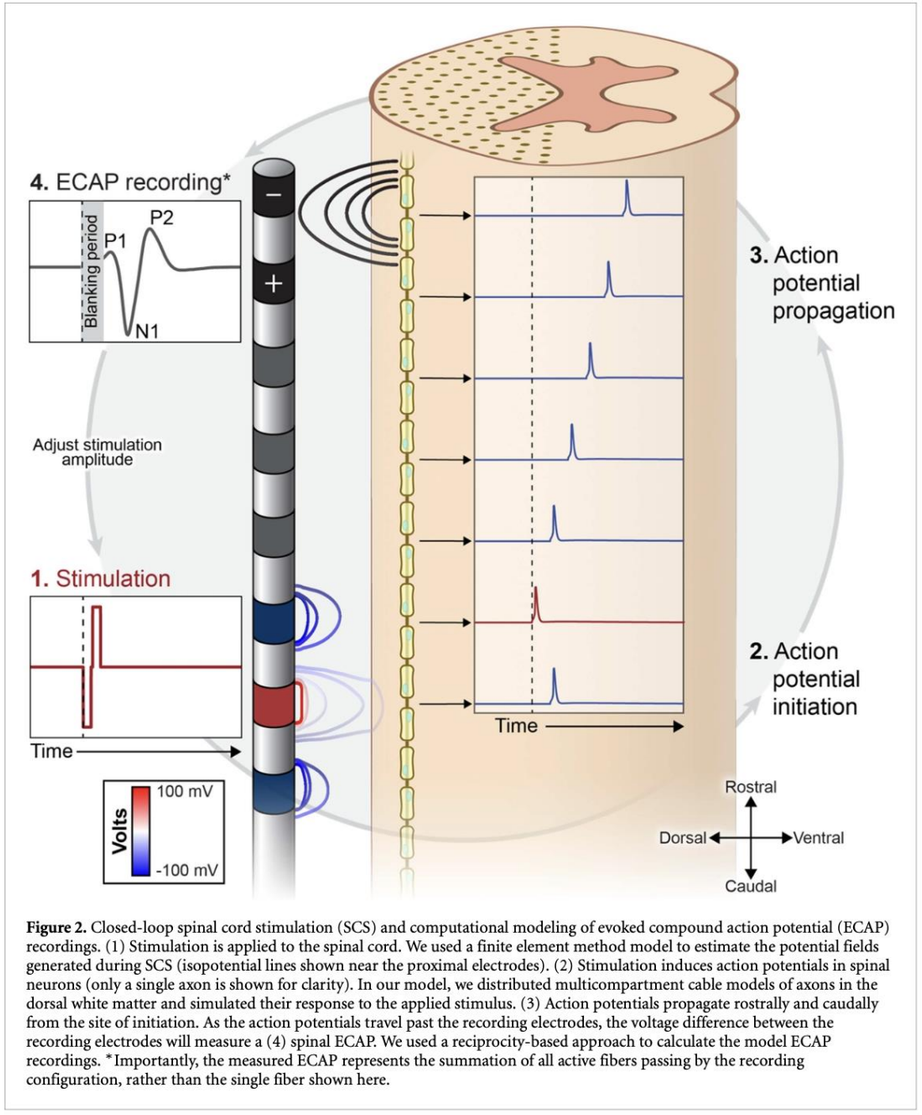


Figure 2. Closed-loop spinal cord stimulation (SCS) and computational modeling of evoked compound action potential (ECAP) recordings. (1) Stimulation is applied to the spinal cord. We used a finite element method model to estimate the potential fields generated during SCS (isopotential lines shown near the proximal electrodes). (2) Stimulation induces action potentials in spinal neurons (only a single axon is shown for clarity). In our model, we distributed multicompartment cable models of axons in the dorsal white matter and simulated their response to the applied stimulus. (3) Action potentials propagate rostrally and caudally from the site of initiation. As the action potentials travel past the recording electrodes, the voltage difference between the recording electrodes will measure a (4) spinal ECAP. We used a reciprocity-based approach to calculate the model ECAP recordings. *Importantly, the measured ECAP represents the summation of all active fibers passing by the recording configuration, rather than the single fiber shown here.

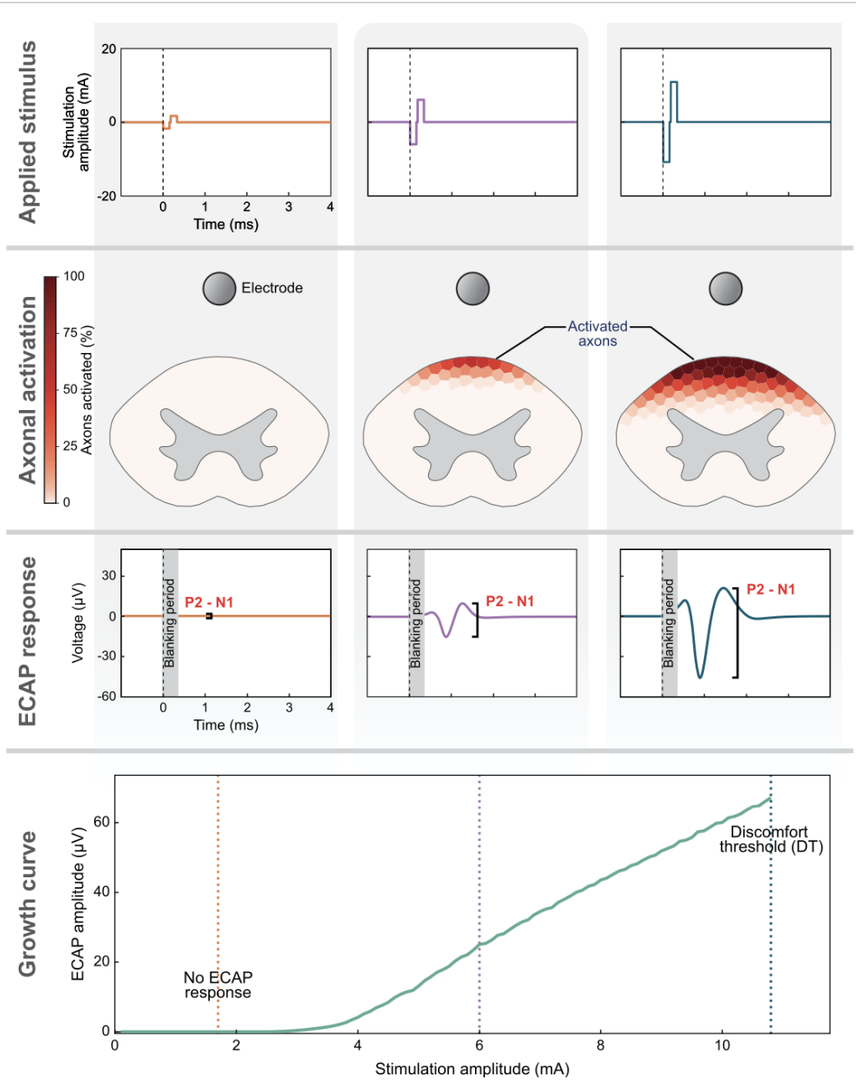


Figure 3. The evoked compound action potential (ECAP) growth curve. The ECAP growth curve is the relationship between the stimulation amplitude and the corresponding ECAP amplitude. The left column shows the applied stimulus (top), example neural activation (2nd row), and simulated ECAP response (3rd row) at a low stimulus amplitude (1.7 mA) in which no neural activity/ECAP is generated. The middle and right columns show the same parameters for both a moderate stimulus (6.0 mA) and high stimulus (10.8 mA), respectively. The bottom row shows the growth curve summarizing the relationship between the stimulation amplitude and ECAP response. Each dashed vertical line shows the corresponding point on the growth curve to the column above.

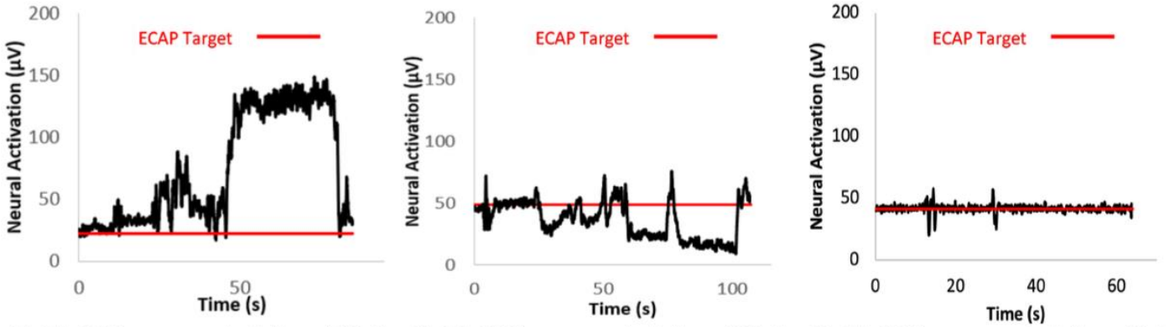
OPEN ACCESS

ECAP-controlled closed-loop versus open-loop SCS for the treatment of chronic pain: 36-month results of the EVOKE blinded randomized clinical trial

Nagy A Mekhail ,[1] Robert M Levy,[2] Timothy R Deer ,[3] Leonardo Kapural,[4] Sean Li,[5] Kasra Amirdelfan,[6] Jason E Pope,[7] Corey W Hunter,[8] Steven M Rosen,[9] Shrif J Costandi ,[1] Steven M Falowski,[10] Abram H Burgher,[11] Christopher A Gilmore,[12] Farooq A Qureshi,[13] Peter S Staats,[5] James Scowcroft,[14] Tory McJunkin,[15] Jonathan Carlson,[16] Christopher K Kim,[3] Michael I Yang,[17] Thomas Stauss,[18] Erika A Petersen,[19] Jonathan M Hagedorn ,[20] Richard Rauck,[12] Jan W Kallewaard,[21,22] Ganesan Baranidharan,[23] Rod S Taylor,[24] Lawrence Poree,[25] Dan Brounstein,[26] Rui V Duarte ,[26,27] Gerrit E Gmel,[26] Robert Gorman,[26] Ian Gould,[26] Erin Hanson,[26] Dean M Karantonis,[26] Abeer Khurram,[26] Angela Leitner,[26] Dave Mugan,[26] Milan Obradovic,[26] Zhonghua Ouyang,[26] John Parker,[26] Peter Single,[26] Nicole Soliday,[26] The EVOKE Study Group

C Neural activation accuracy with Closed-Loop

The basis for physiological CL-SCS therapy is to deliver personalized ECAP therapy with high accuracy (i.e., low variability). More consistent activation of target structures should in turn trigger more consistent activation of inhibitory interneurons in the spinal grey matter. As such, a lower deviation from the prescribed target will better exploit the putative mechanisms of action of SCS. Examples of neural accuracy to the prescribed ECAP target in unique patients are seen in c1 to c3 during a sequence of posture changes.

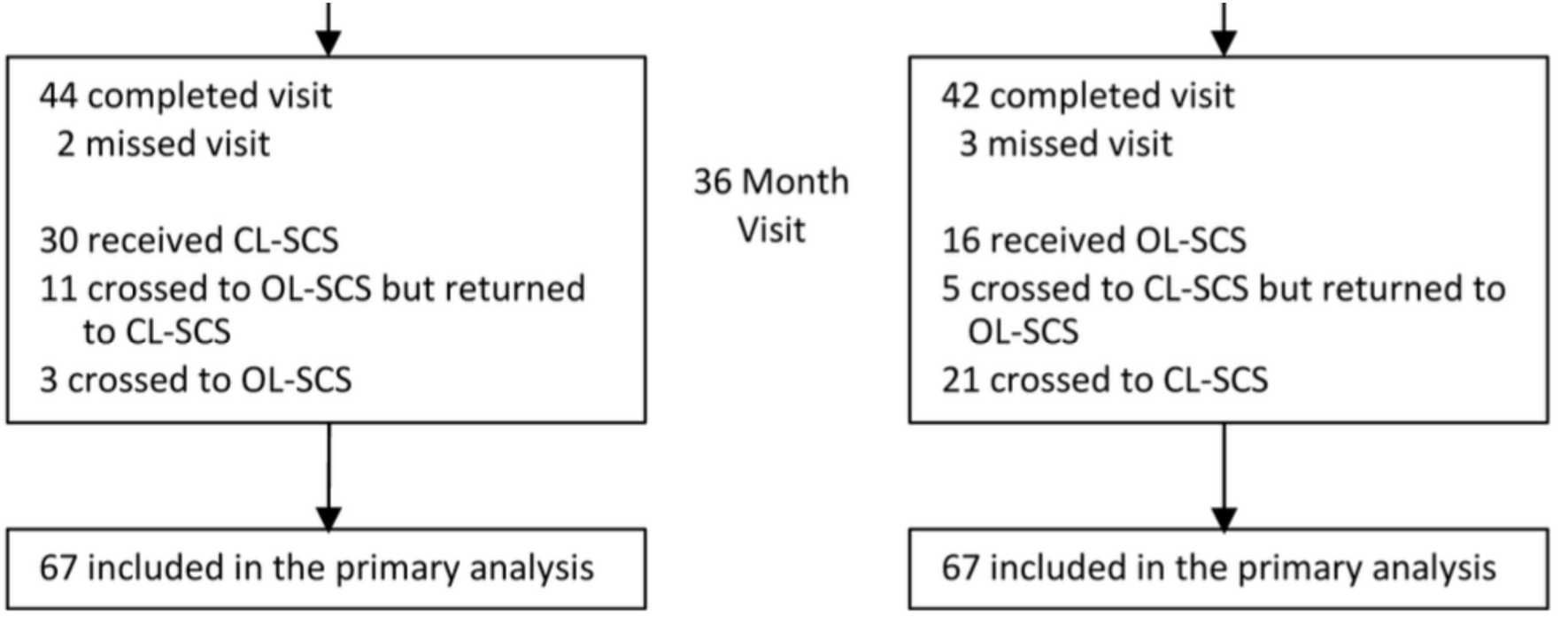


C1 OL-SCS, average deviation of 68µV **C2** OL-SCS, average deviation of 20µV **C3** CL-SCS, average deviation of 3µV

Figure 1 ECAP-controlled closed-loop SCS fundamentals. AP, action potential; CL, closed-loop; ECAP, evoked compound action potential; OL, open-loop; SCS, spinal cord stimulation.

CONCLUSIONS

At 36-month follow-up, ECAP-controlled CL-SCS resulted in superior and durable improvements in patient reported outcomes of pain, sleep, disability, emotional function, and health-related quality of life and the composite holistic treatment response. Greater neural activation and increased accuracy of spinal cord activation were also observed with CL-SCS. This evaluation demonstrated the long-term benefits of objective measurement, accurate therapy delivery, and enhanced neural activation achieved with CL-SCS therapy.



rds of Reporting Trials (CONSORT) diagram. AE, adverse event; CL-SCS, closed-loop SCS;

Competing interests NM reports personal fees from Saluda Medical for acting as independent medical monitor for the EVOKE study during the conduct of the study; he reports receiving grants from Neuros and Mesoblast, as well as consulting as a medical monitor for Nevro, Vivex, Mainstay, and Vertos outside the submitted work. RL is an uncompensated consultant for Nalu, Saluda Medical, and Mainstay Medical and has stock options from Nalu and Saluda Medical obtained before 2019, not exercisable through the duration of his term as International Neuromodulation Society President and editor-in-chief of the journal Neuromodulation: Technology at the Neural Interface. TD reports personal fees from Saluda Medical during the conduct of the study; consultancy for Axonics, Abbott, Nalu, Vertos, SpineThera, Mainstay, Cornerloc, Ethos, SPR Therapeutics, Medtronic, Boston Scientific, PainTeq, Tissue Tech, Spinal Simplicity, and Avanos outside the submitted work. He is a minor equity holder for Saluda Medical, Nalu, SpineThera, Stimgenics, Vertiflex, Vertos, and Bioness and an advisory board member for Abbott, Vertos, Nalu, SPR Therapeutics, and Tissue Tech. LK reports receiving grants from Nevro, Neuros, Avanos, Medtronic, Neuralace, and Xalud Therapeutics and financial support from Nevro, Avanos, and Saluda Medical outside the submitted work. SL reports receiving grants and personal fees from Saluda Medical during the conduct of the study; he reports grants from Avanos, Boston Scientific, Nalu Medical, SPR Therapeutics, Averitas Pharma, Biotronik, SGX Therapeutics, and PainTeq, as well as consultancy for Abbott, Avanos, Boston Scientific, Nevro, SPR Therapeutics, Averitas Pharma, Biotronik, Nalu Medical, and PainTeq, outside the submitted work, as well as holding stock options for Nalu Medical. KA reports consultancy for Medtronic, Nevro, Boston Scientific, Nalu, Presidio, Biotronik, Mesoblast, Vivex Laboratories outside the submitted work. JP reports research and consulting fees from Saluda Medical during the conduct of the study; consultancy for Abbott, Medtronic, Saluda Medical, Flowonix, SpineThera, Vertos, Vertiflex, SPR Therapeutics, Tersera, Aurora, Spark, Ethos, Biotronik, Mainstay, WISE, Boston Scientific, and Thermaquil outside the submitted work; has received grant and research support from: Abbott, Flowonix, Aurora, Painteq, Ethos, Muse, Boston Scientific, SPR Therapeutics, Mainstay, Vertos, AIS, and Thermaquil outside the submitted work; and is a shareholder of Vertos, SPR Therapeutics, Painteq, Aurora, Spark, Celeri Health, Neural Integrative Solutions, Pacific Research Institute, Thermaquil, and Anesthetic Gas Reclamation. CH reports grants from Saluda Medical during the conduct of the study; consultancy fees from Genecentrix outside the submitted work. SC reports grants from Cleveland Clinic during the conduct of the study; and grants from Vertos, Mainstay, and Vivex outside the submitted work. 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PAPER

Epidural spinal cord recordings (ESRs): sources of neural-appearing artifact in stimulation evoked compound action potentials

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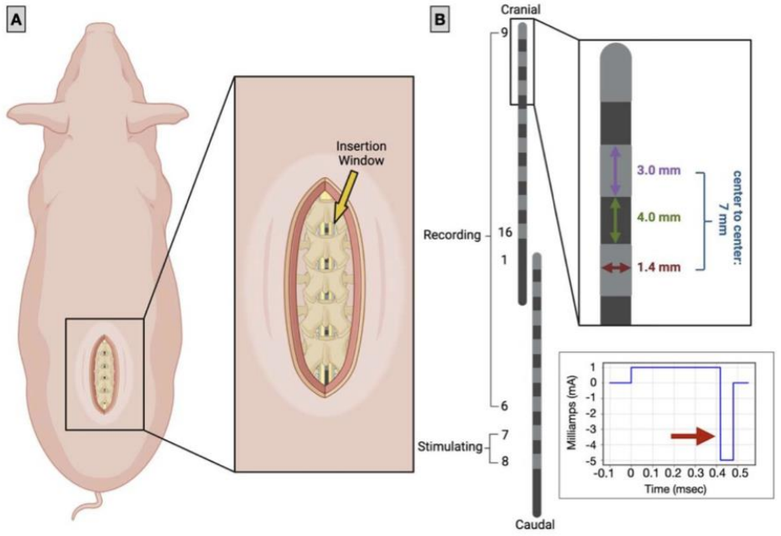
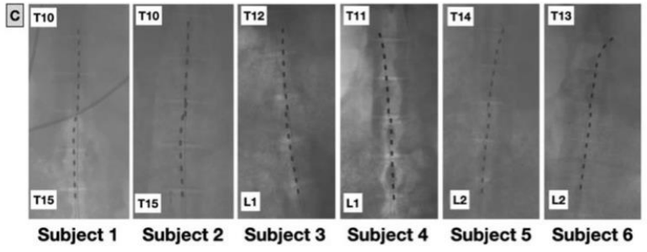




D

1 Baseline Recordings	2 Vecuronium Recordings	3 Post-mortem Recordings
• Asymmetrical, charge-balanced, biphasic waveform • Dose response curves generated above, at, and below motor threshold • All stimulation parameters repeated, swapping the short cathodic phase between contact 7 and 8 • 1 repeat of all measures	• No visible response of muscles to stimulation • Asymmetrical, charge-balanced, biphasic waveform • Dose response curves generated above, at, and below motor threshold • All stimulation parameters repeated, swapping the short cathodic phase between contact 7 and 8	• No EKG signal or visible response to stimulation • Asymmetrical, charge-balanced, biphasic waveform • Dose response curves generated above, at, and below motor threshold • All stimulation parameters repeated, swapping the short cathodic phase between contact 7 and 8

Indikationen zur SCS

- *Ausstrahlende Nervenschmerzen*
-Postoperative Rücken-/Beinschmerzen
-Stumpf- o. Phantomschmerzen
-Leistenschmerzen nach OP

-Schmerzen bei Durchblutungsstörungen
(p AVK, Sklerodermie, Mb. Raynaud)
-Diabetische Polyneuropathie

-Angina pectoris

Tabelle (gestaltbar): Häufigste Operationen in Krankenhäusern

Die 50 häufigsten Operationen der vollstationären Patientinnen und Patienten in Krankenhäusern (Rang, Anzahl, Anteil in Prozent). Gliederungsmerkmale: Jahre, Deutschland, Geschlecht, Art der Operation Info

Diese Tabelle bezieht sich auf:
Jahr: 2024, **Geschlecht**: Alle Geschlechter

Art der Operation	Sachverhalt		
	Rang	Anzahl	Anteil an allen Operationen in Prozent
Alle Operationen Info		16.310.526	100,0
Summe der 50 häufigsten Operationen Info		7.698.016	47,2
5-469 Andere Operationen am Darm	1	381.456	2,3
5-032 Zugang zur Lendenwirbelsäule, zum Os sacrum und zum Os coccygis	2	369.441	2,3
5-758 Rekonstruktion weiblicher Geschlechtorgane nach Ruptur, post partum (Dammriss)	3	343.149	2,1
5-513 Endoskopische Operationen an den Gallengängen	4	300.475	1,8
5-820 Implantation einer Endoprothese am Hüftgelenk	5	281.086	1,7
5-749 Andere Sectio caesarea	6	251.033	1,5

SCS-Fallbeispiele

PSPS I / II
sDPN

Closed-Loop

SCS bei PSPS I

W, 52 J, Lehrerin

Nackenschmerzen >10 Jahre

Belastungsabhängig, Ausstrahlung Schultern L>R, BWS, beide Arme (inkostant L-R)

VAS min 4 max 8-9/10

Keine Parese, kein sensibles Defizit OE

Schmerzbedingte Schon-/Fehlhaltung

Analgetika und Co-Analgetika bis WHO III/Opioide (2x8mg Hydromorphon), Cannabinoide nur NW

Botox-Injektionen mit nachlassendem Effekt

Facettten-Injek./ -denervationen mit nur temporärem Effekt (C5/6, 6/7, 7/Th1)

SCS bei PSPS I

CT- / MRT: Degenerationen, BS-Protrusion HWK5/6 mit relative Stenose
multisegmentale Foramenstenose

Indikation HWS-OP?

Patientin lehnt HWS-OP ab (Fusion/Foraminotomie)

Ehemann hat PSPS II nach LWS-OPs…

Alternative: zervikale SCS, Elektroden-Implantation und Testphase

Bedenkzeit

SCS bei PSPS I

Entschluß zur zervikalen SCS

Perkutane Elektroden-Implantation und Testphase

VAS↓: min 0 max 2-3/10

Stimulator-Implantation links abdominel

NeuroSense-Aktivierung (Aufladung 1x/Woche)

Follow-up alle 3-6 Monate

SCS bei PSPS II

W, 47 J, BMI 36

Schmerzursache: zervikale Degeneration; Ventrale Fusion HWK 6/7 03/2022

Schmerz-areal: Nacken, Schultern, beide Arme, Dermatom C6/7

Dauerschmerz plus Attacken, VAS min 4 max 7-8

Arbeitsunfähig seit 02/2022

Analgetika: Metamizol 500 mg, Pregabalin 100 mg, Amitriptylin 10 mg

Vorherige Behandlungen: Analgetika und Co-Analgetika, Physio, Infiltrationen, stationäre Multimodale Schmerztherapie

Vorerkrankungen: Hypertonie, OSAS, Adipositas, Knie-OP

SCS bei PSPS II

11/23: Elektrodenimplantation: zwei Elektroden HWK 3-6

Testphase mit Extensionen und ENS für 7 Tage

Tonische Stimulation, Anpassung der Intensität durch Patientin

Angenehme Parästhesien in beiden Armen, Nacken und Schultern

Schmerzlinderung >50%, Reduktion der Analgetika (Pregabalin 50mg)

Tag 5: Stim OFF → signifikante Schmerzzunahme → Stim ON

SCS bei PSPS II

Tonische SCS – Schmerzlinderung >50%, VAS 2-4

Reduktion der Analgetika Pregabalin und Metamizol

Lageabhängige unangenehme Parästhesien

Stimulator-Implantation links abdominel

1st postop. Tag: ECAP-Ableitung bei induzierten Bewegungen

Definition der unteren/oberen Schwellen und Aktivierung von CL

24/7 NeuroSense Anpassung der Stimulationsintensität durch Pat.

Berechnung der Aufladung alle 11 Tage

SCS bei PSPS II

18 Monate postoperativ:

SCS 24/7 aktiv

Anhaltende Schmerzlinderung >50%

Metamizol und Pregabalin abgesetzt

Aufladung 1x / Woche für ca. 1 h

Patientin ist „sehr zufrieden“

SCS bei sDPN

68 J, W
DM II >20 Jahre

Dauerschmerzen und belastungsbhängige Schmerzzunahme
Ansteigende Schmerzen im Tagesverlauf VAS 6-9

Aktuelle Analgetika:
Pregabalin 200-100-200 mg/d
Duloxetin 60 mg 1-0-0
Oxycodon 4 x 10 mg/d
Metamizol 500-1000 mg bei Bedarf

Cannabinoide: NW
Capsaicin 8% Patch: kein Effekt

SCS bei sDPN

SCS Testphase
(zervikale/thorakale Elektrode): > 50% Schmerzlinderung
Weniger belastungsabhängige Schmerzen OE>UE
Verbesserte Funktionalität der Hände
(prä-op. iv. single-shot und orale Antibiose während Testphase empfohlen)

<u>Follow-up 6 Monate:</u>
SCS 24/7
Schmerzniveau VAS 2-5
Med: Pregabalin 100-0-150 mg/d
Oxycodon 5 – 10 mg bei Bedarf
Duloxetin 60 mg 1-0-0
Lebensqualität↑

SCS bei sDPN

SCS-Parameter:

-Gr. A: Parästhesie-basierte SCS OE/UE 70 Hz
-Gr. B: NeuroSense OE
-Gr. C: DTM OE/UE 300 Hz

Patienten-Präferenz:
-Gr. B: tagsüber
-Gr. A: nachts, sub-threshold
-Gr. C: kurze Gebrauchszeit (<1%)

Klinische Erfahrungen

SCS-Elektrodenimplantation:

Sensing-Funktion

mit den proximalen/

distalen Kontakten!

Klinische Erfahrungen

Abdominelle Implantation bevorzugt

Weniger lokale Schmerzen und Fremdkörper-Irritation

Bluetooth-Verbindung

Einfache, intuitive und praktische Bedienung der Software (Patient/Arzt)

Klinische Erfahrungen

Aufladeprobleme mit Abbruch

Aufladesystem unhandlich, groß

Abbruch der Telemetrie

Unterschiedliche Kabelstecker (Kommunikator…)

…

1 Pat.: Austausch wiederaufladbar

zu nicht-wiederaufladbar

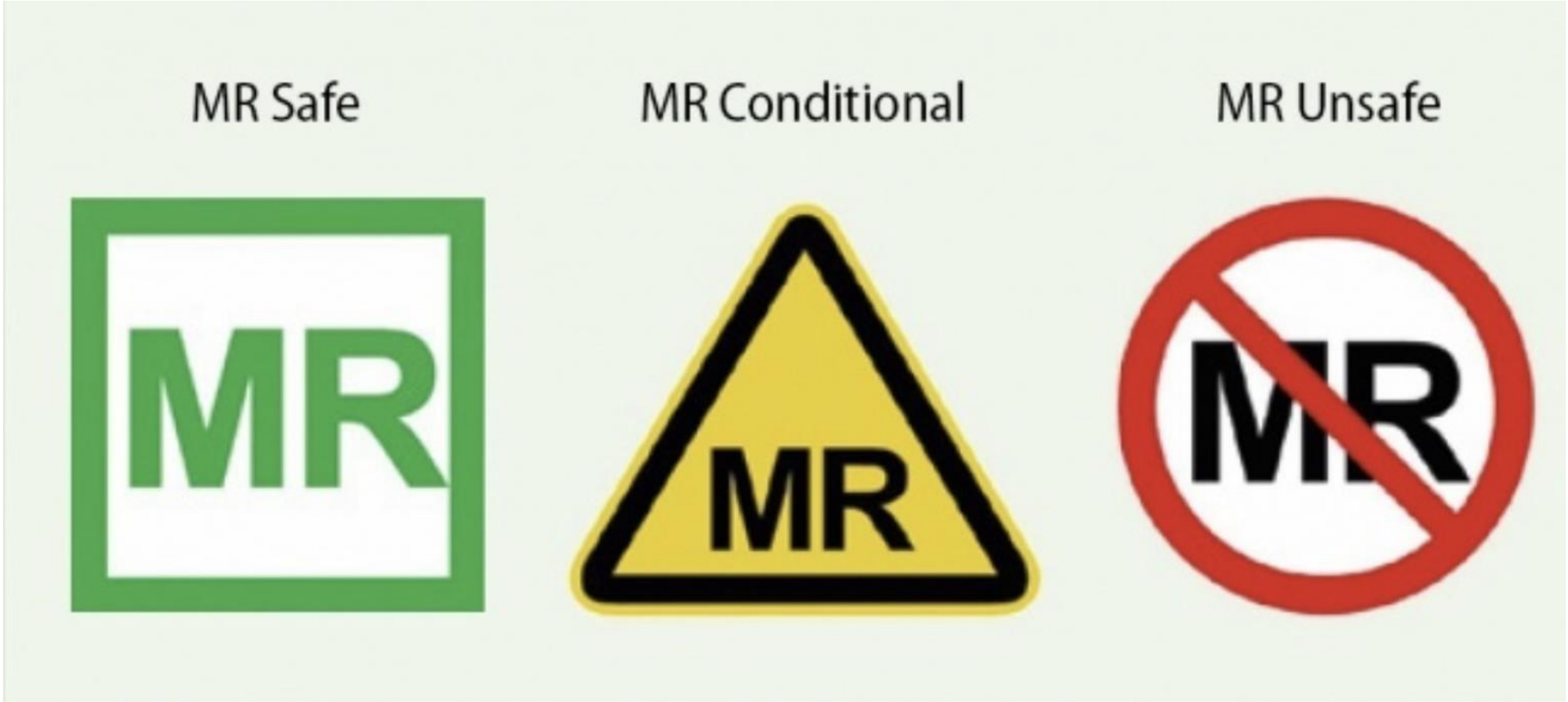
Klinische Erfahrungen

Indikation aktuell für das modernste Stimulationssystem

Indikation „wiederaufladbar“ vs. „nicht-wiederaufladbar“

IPG-Wechsel: neuester Stimulator

OFF-Label: ONS/PNS, MCS (DBS)



Standardized symbols and terms used in MR labeling, which are created for MR product approval at worldwide regulatory agencies.

MR:COMP

3 Tesla MRT-Tauglichkeit!!!

What´s next???

- Neue Wellenformen
- Kombinationsparameter und zyklische Stimulationsformen
- Verbesserte Stimulatoren
- Digitale Gesundheitsanwendungen
- Neue Elektroden
- Verbessertes CL-SCS und weitere Biomarker
- Verbesserte Patientenselektion und neue Indikationen
- …

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Sleep Medicine

journal homepage: www.elsevier.com/locate/sleep

Adaptive spinal cord stimulation improves restless legs syndrome: Case report, literature review, and mechanistic hypothesis

Marshall T. Holland [a,*], Mena N. Mekhail [b], Garrett Thrash [c], Tony George [d], Dave Mugan [b], Christopher Paul [e], Prasad Shirvalkar [f], Warren Grace [g], Timothy Deer [h], Keith McGregor [i], Rocio Vazquez do Campo [j], Christopher J. Earley [k], Harrison C. Walker [j]

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Positionspapier

Thieme

Stellenwert der Rückenmarkstimulation bei schmerzhafter diabetischer Polyneuropathie

Significance of spinal cord stimulation in painful diabetic polyneuropathy

Autorinnen/Autoren

Dan Ziegler[1‡], Thorsten Luecke[2‡], Rezvan Ahmadi[3], Jaroslaw Maciaczyk[4], Erhard Siegel[5], Claudia Sommer[6], Dirk Rasche[7]

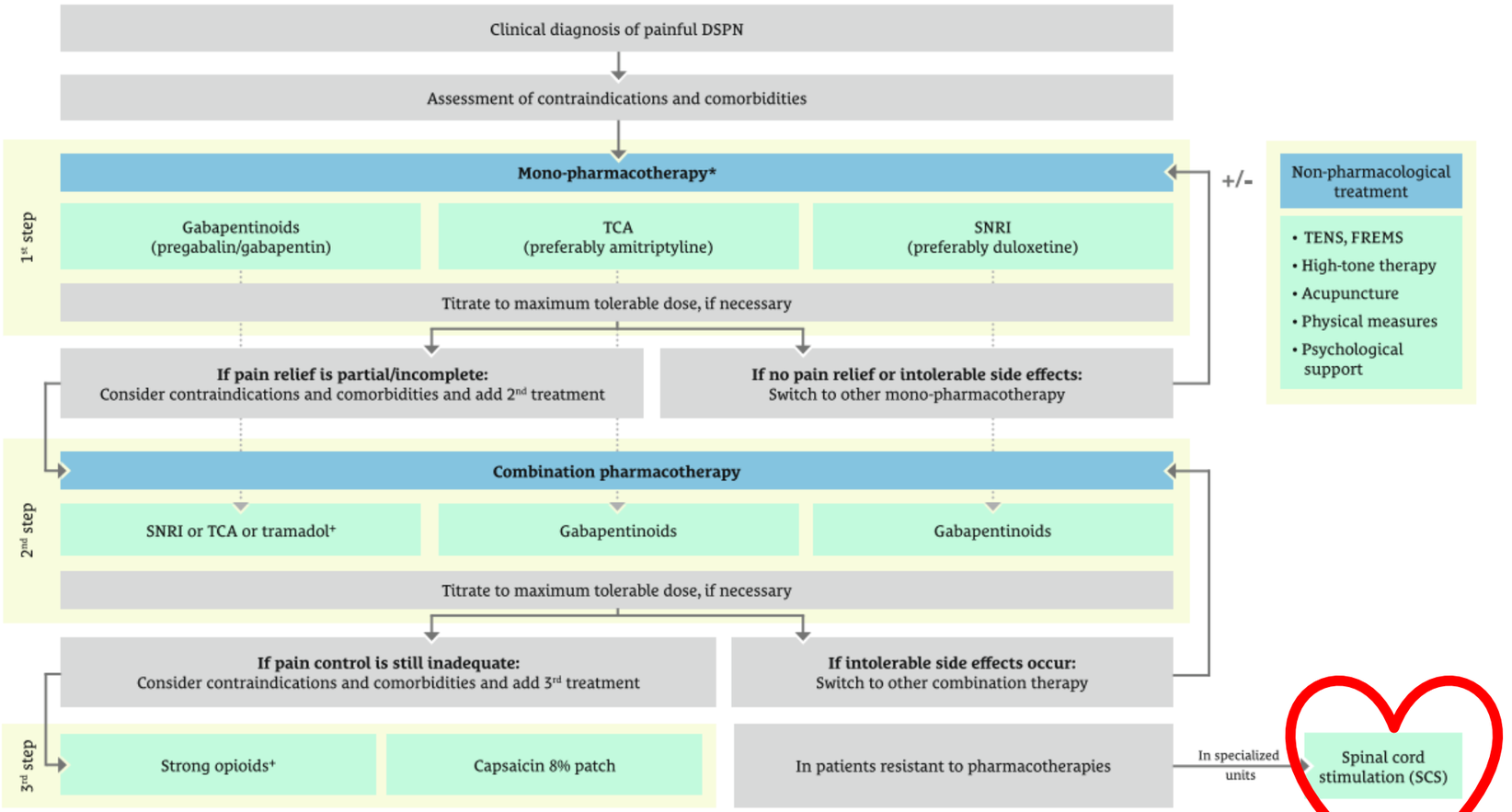

Fig. 3 – Consensus recommendation of an algorithm for analgesic pharmacotherapy and non-pharmacological treatment options in painful DSPN in clinical practice. Footnotes/abbreviations: * Pathogenetically oriented treatment approaches may also be considered; DSPN: diabetic sensorimotor polyneuropathy; TCA: tricyclic antidepressants; SNRI: serotonin-norepinephrine reuptake inhibitors; TENS: transcutaneous electrical nerve stimulation; FREMS: frequency-modulated electromagnetic neural stimulation; + for short term use only, whenever possible.

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Effects of Multiple Waveforms on Patient Preferences and Clinical Outcomes in Patients Treated With Spinal Cord Stimulation for Leg and/or Back Pain

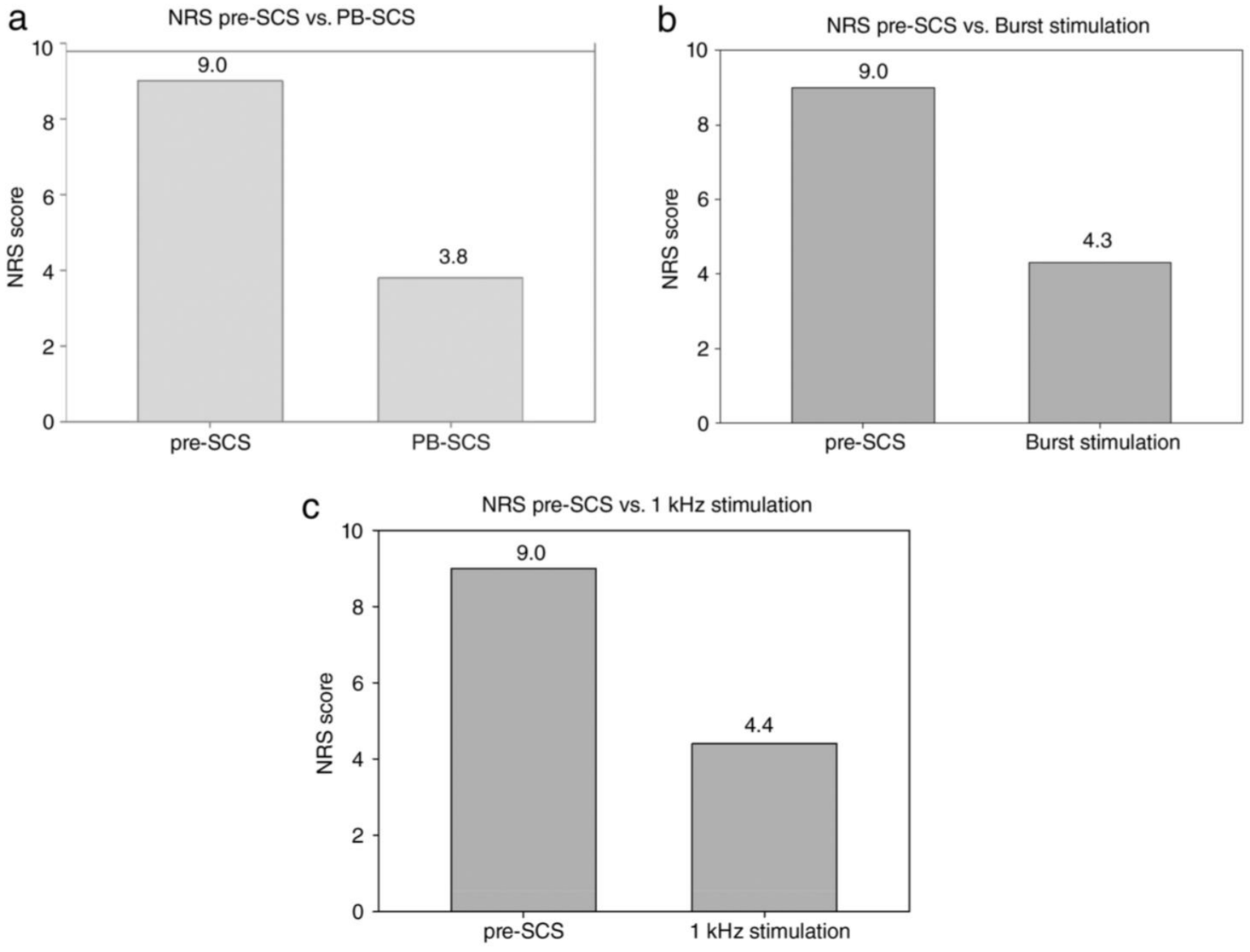
Genni Duse, MD*; Claudio Reverberi, MD†; Alessandro Dario, MD‡

Objectives: We present the results of a prospective, randomized, crossover, single-blind, study in which each patient is in control of himself. The aim was to evaluate subperception-based (SP-SCS) waveforms in previously implanted spinal cord stimulation (SCS) patients with leg and/or back pain due to failed back surgery syndrome, who experienced only paresthesia-based stimulation (PB-SCS). Patients with PB-SCS experience in SCS was 4.7 years (SD 2.9).

Materials and Methods: We enrolled 28 consecutive patients. Treatment consisted of seven days of PB-SCS, followed by a randomized, crossover phase to test SP-SCS waveforms (burst or 1 kHz frequency, seven days each). A maximum of three-day washout period separated each stimulation program.

Results: Statistically significant pain relief was maintained using both SP-SCS waveforms, as indicated by the differences between the pre-PB-SCS numeric pain rating score (mean 9) and the pain score after using the burst program (pain relief 52%) or the 1 kHz program (pain relief 51%). There was no statistically significant superiority among PB-SCS, burst, and 1 kHz stimulation. Overall, 50% of patients preferred PB-SCS, 42% chose to move to SP-SCS stimulation, one patient was unable to give feedback, and one patient was unsuccessful with any type of stimulation. Overall, SCS has shown to be successful in pain relief and the patients switched to a SP-SCS waveform only for having higher pain relief.

Conclusions: There was a high heterogeneity regarding waveform preference, with patients who preferred to feel the tingling sensation and those who chose a SP-SCS option, mainly for greater pain relief. In general, SCS is successful, resulting in high pain relief, improvements in quality of life, and little depression. Overall, 42% patients benefited from the novel SP-SCS stimulation waveforms.


a
NRS pre-SCS vs. PB-SCS
NRS score
10
8
6
4
2
0
9.0
3.8
pre-SCS
PB-SCS
b
NRS pre-SCS vs. Burst stimulation
NRS score
10
8
6
4
2
0
9.0
4.3
pre-SCS
Burst stimulation
c
NRS pre-SCS vs. 1 kHz stimulation
NRS score
10
8
6
4
2
0
9.0
4.4
pre-SCS
1 kHz stimulation

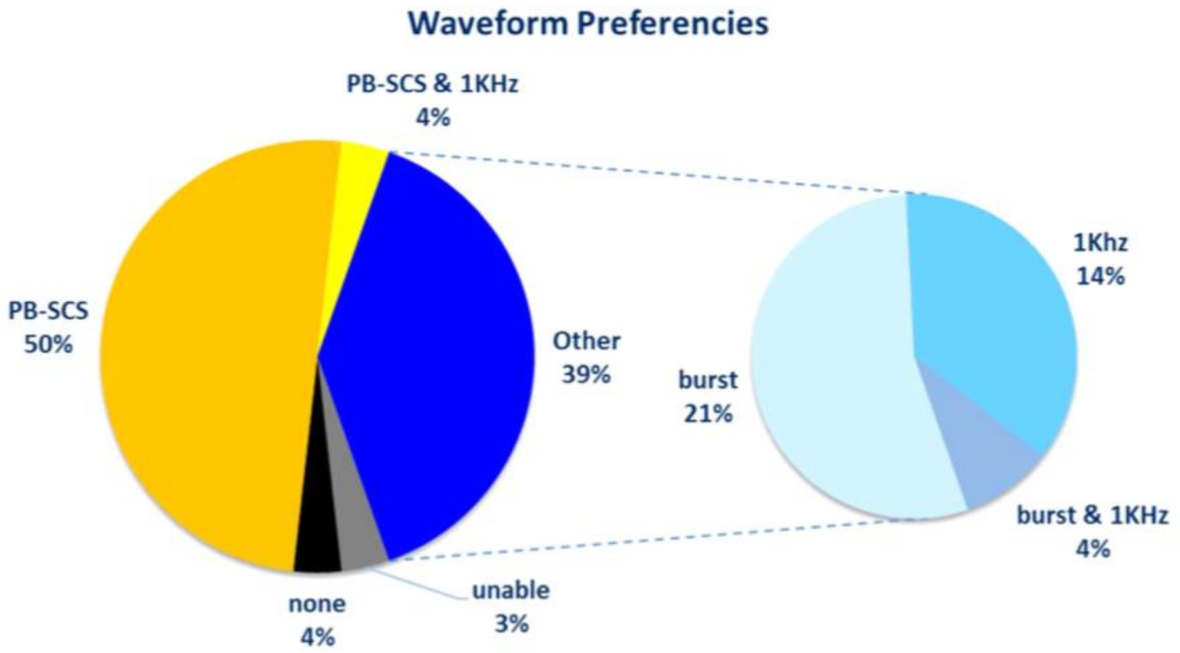


Figure 3. Preference distribution among the different stimulation options tested by the patients. Overall, 50% of patients continued to prefer tonic stimulation (PB-SCS), 21% preferred burst, 14% 1 kHz, 4% both subperception programs, 4% tonic and 1 kHz alternated, one patient unable to discriminate and one no responder to any kind of waveform. It was determined after the study during the last follow-up visit; all the patients are still using the waveform chosen [Correction added on 06 February 2019, after first online publication: Figure 3 has been updated for clarity of the waveform preferences.]. [Color figure can be viewed at wileyonlinelibrary.com]

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Chronic Pain Is a Brain Network Disorder

Julian C Motzkin [1] [2], Bin He [3], Kalpna Gupta [4] [5], Prasad Shirvalkar [1] [2] [6]

Affiliations + expand

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EJP
European Journal of Pain

POSITION PAPER

Assessment and manifestation of central sensitisation across different chronic pain conditions

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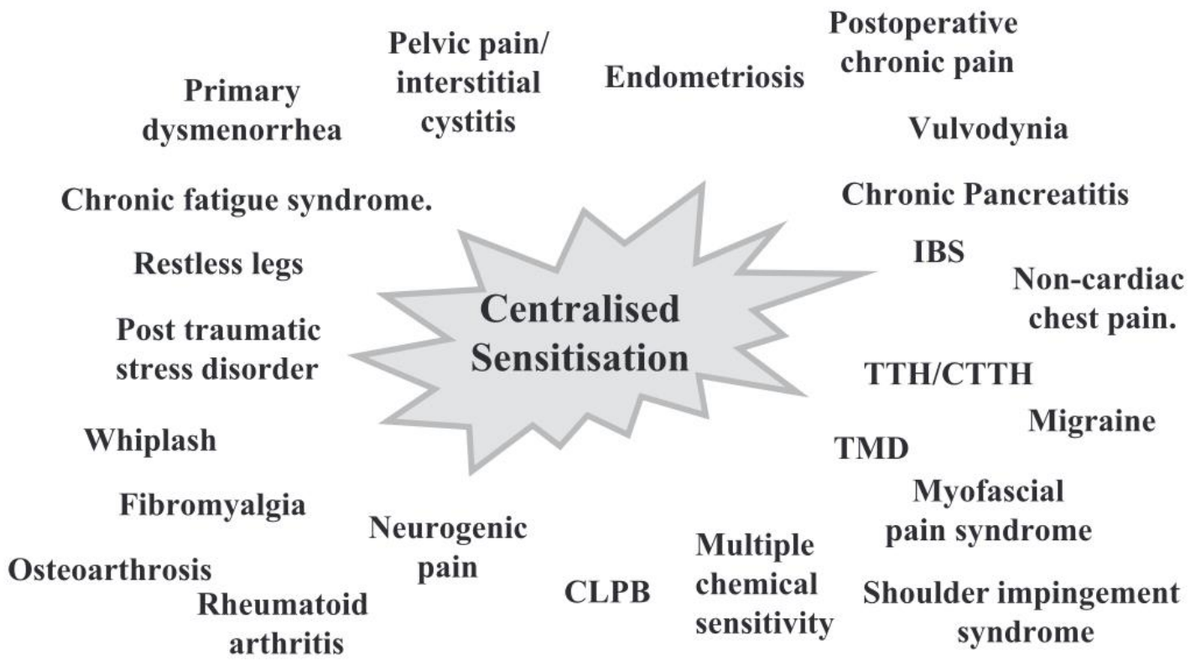

Figure 2 A listing of the many chronic pain conditions in which different aspects of the central sensitisation phenomenon have been assessed and validated mechanistically with quantitative sensory testing. (OA = Osteoarthritis, CLBP = Chronic Low Back Pain, TMD = Temporomandibular Disorders, TTH/CTTH = Tension Type Headache/Chronic Tension Type Headache, IBS = Irritable Bowel Syndrome).

Take Home Message

Unzureichende Symptomkontrolle

Klinischer Bedarf für **Neuromodulation**

Grundlagenforschung

…

Real-World-Datenbanken

Technischer Fortschritt

Digitalisierung und KI

Vielen Dank
für Ihre Aufmerksamkeit!

dirk.rasche  uksh.de